

NOAA COASTAL MAPPING PROGRAM PROJECT COMPLETION REPORT

PROJECT MI1001F-CM-N

Point Betsie to Stony Lake, Michigan

Introduction

NOAA Coastal Mapping Program (CMP) Project MI1001F-CM-N provides highly accurate digital shoreline data for a portion of Lake Michigan from Point Betsie to Stony Lake, Michigan including various tributaries. MI1001F-CM-N is a subproject of a larger project, MI1001-CM-N, which covers the entire eastern shore of Lake Michigan. The Geographic Cell (GC) may be used in support of the NOAA Nautical Charting Program (NCP) as well as geographic information systems (GIS) for a variety of coastal zone management applications.

Project Design

The Requirements Branch (RB) of the Remote Sensing Division (RSD) formulated the photographic mission instructions for this project following the guidelines of the Photo Mission Standard Operating Procedures. The instructions discussed the project's purpose, geographic area of coverage, photographic requirements, Global Positioning System (GPS) data collection procedures and guidelines for both kinematic and static surveys, and data recording and handling instructions. RB also created project layout diagrams, flight maps, and input files for the aircraft's flight management system.

Field Operations

The field operations consisted of the collection of static and kinematic GPS data, Inertial Measurement Unit (IMU) data, the acquisition of digital aerial imagery, and the collection of ground control points. Photographic mission operations for MI1001-CM-N were conducted from September 7, 2010 to July 5, 2011 with the NOAA King Air (N68RF) aircraft. Two hundred and four flight lines of color (RGB) imagery, along with simultaneous black & white infrared (IR) imagery, were acquired with an Applanix Digital Sensor System (DSS) 439 aerial camera at a nominal altitude of 10,000 feet, resulting in an approximate ground sample distance (GSD) of 0.35 meters. For subproject MI1001F-CM-N, only nineteen flight lines were used.

Fugro EarthData, Inc. was contracted by RSD to collect ground control points (GCPs). A total of two GCPs were established for MI1001F-CM-N using static GPS techniques. Two additional photo-identifiable check points were also occupied at well-defined discrete locations. Survey field work was performed on September 23, 2014 and October 7, 2014.

GPS Data Reduction

The GPS/IMU data was processed by RSD personnel to yield precise positions and orientations of camera centers for application as photogrammetric control in the aerotriangulation phase of project completion. A local GPS base station was established for use as a reference station for kinematic GPS processing operations. The position of the base station was determined using the

NGS Online Processing User Service (OPUS), which computed fixed baseline solutions from nearby CORS stations. The kinematic GPS data was processed using Applanix POSPAC (ver. 6.1) software in January 2013. For further information refer to the Airborne Positioning and Orientation Reports (APOR) on file with other project data within the Remote Sensing Division Electronic Data Library. All positional data is referenced to the North American Datum of 1983 (NAD 83).

Aerotriangulation

Routine softcopy aerotriangulation methods were applied to establish a network of precise camera positions and other control for mapping, and to provide model parameters and orientation elements required for digital compilation. This work was completed by Fugro personnel in January 2015 using a softcopy photogrammetric workstation. The RGB and IR images were measured and adjusted as two separate blocks using Intergraph ImageStation Automatic Triangulation (ISAT) software (v. 13.0), which was used to perform automatic and interactive point measurements of tie points. Upon successful completion of the aerotriangulation process, the RMS of the standard deviations of the residuals for each aerotriangulated ground point were used to compute a predicted horizontal circular error of 0.57 meters for the color block and 0.55 meters for the IR block, based on a 95% confidence level. As a final check, the GPS-surveyed check points were measured in the imagery and compared to their surveyed coordinates. An Aerotriangulation Report was completed and is on file with other project data within the RSD Electronic Data Library.

Compilation

The data compilation phase of the project was initiated by Fugro Geospatial, Inc. personnel in January 2015. Digital mapping was performed using the Feature Extraction software module within Intergraph's Stereo Softcopy Kit (SSK) photogrammetric suite of software. Feature identification and the assignment of cartographic codes were based on image analysis of the project digital images and information extracted from the appropriate NOAA Nautical Charts, U.S. Coast Guard Light List and other ancillary sources. Feature attribution was assigned in compliance with the Coastal Cartographic Object Attribute Source Table (C-COAST). Selected features were further modified with additional descriptive information to refine general classification.

Spatial data accuracies for Project MI1001F-CM-N were determined according to standard Federal Geographic Data Committee (FGDC) practices. Cartographic features were compiled to meet a horizontal accuracy of 1.1 meters at the 95% confidence level. This predicted accuracy of compiled well-defined points is based on a doubling of the circular error derived from the aerotriangulation statistics.

The following table provides information on the imagery used to complete this project:

Date	Time (UTC)	Color Imagery		Infrared Imagery		Lake Level
		Roll	Images	Roll	Images	
4-JUL-2011	15:49 – 15:53	11NC51	15955 – 15980	11NR30	9893 – 9914	176.3
4-JUL-2011	15:59 – 16:06	11NC51	15981 – 16028	11NR30	9915 – 9962	176.3

4-JUL-2011	16:12 – 16:21	11NC51	16029 – 16083	11NR30	9963 – 10017	176.3
4-JUL-2011	16:25 – 16:35	11NC51	16085 – 16149	11NR30	10019 – 10083	176.3
4-JUL-2011	16:45 – 16:54	11NC51	16151 - 16213	11NR30	10085 – 10147	176.3
4-JUL-2011	16:59 – 17:09	11NC51	16216 – 16280	11NR30	10150 – 10214	176.3
4-JUL-2011	17:13 – 17:18	11NC51	16281 – 16311	11NR30	10215 – 10246	176.3
4-JUL-2011	17:33 – 17:38	11NC51	16335 – 16364	11NR30	10269 – 10299	176.3
4-JUL-2011	17:42 – 17:47	11NC51	16366 – 16398	11NR30	10301 – 10332	176.3
4-JUL-2011	17:52 – 17:58	11NC51	16399 – 16438	11NR30	10333 – 10372	176.3
4-JUL-2011	18:03 – 18:06	11NC51	16439 – 16457	11NR30	10373 – 10391	176.3
4-JUL-2011	18:11 – 18:16	11NC51	16458 – 16492	11NR30	10392 – 10426	176.3
4-JUL-2011	18:21 – 18:26	11NC51	16493 – 16530	11NR30	10427 – 10464	176.3
4-JUL-2011	18:30 – 18:32	11NC51	16531 – 16542	11NR30	10465 – 10476	176.3
4-JUL-2011	18:35 – 18:38	11NC52	16543 – 16563	11NR31	10477 – 10497	176.3
4-JUL-2011	19:00 – 19:03	11NC52	16689 – 16706	11NR31	10623 – 10641	176.3
4-JUL-2011	19:08 – 19:09	11NC52	16710 – 16717	11NR31	10644 – 10651	176.3

*Lake water levels are given in meters above IGLD 1985 and are based on verified observations at the Ludington station in Michigan. The Low Water Datum (LWD) for Lake Michigan is 176.0 meters.

Quality Control / Final Review

Quality control tasks were conducted during all phases of project completion by a senior member of Fugro. The final QC review was completed in June 2015. The review process included analysis of aerotriangulation results and assessment of the identification and attribution of digital feature data within the GC according to image analysis and criteria defined in C-COAST. The quality control process concluded with an inspection of topological connectivity within the GC using ArcGIS 10.3.1 software. All project data were evaluated for compliance to CMP requirements.

Comparisons of the largest scale NOAA nautical charts with RGB and IR images and compiled project data resulted in creation of the Chart Evaluation File (CEF). The following nautical charts were used in the comparison process:

- 14907, Stony Lake to Point Betsie, MI, 1:120,000 scale, 28th ed., Feb. 2016
(Including 1:10,000 scale insets)
- 14937, Ludington Harbor, MI, 1:5,000 scale, 25th ed., Sep. 2013
- 14938, Manistee Harbor, MI, 1:10,000 scale, 25th ed., Nov. 2015
- 14939, Portage Lake, MI, 1:10,000 scale, 24th ed., Oct. 2015

End Products and Deliverables

The following specifies the location and identification of the products generated during the completion of this project:

Remote Sensing Division Electronic Data Library

- Ground Control Report
- Airborne Positioning and Orientation Report (APOR)
- Aerotriangulation Report
- Project Completion Report (PCR)
- Project database
- GC11085 in shapefile format
- Chart Evaluation File in shapefile format

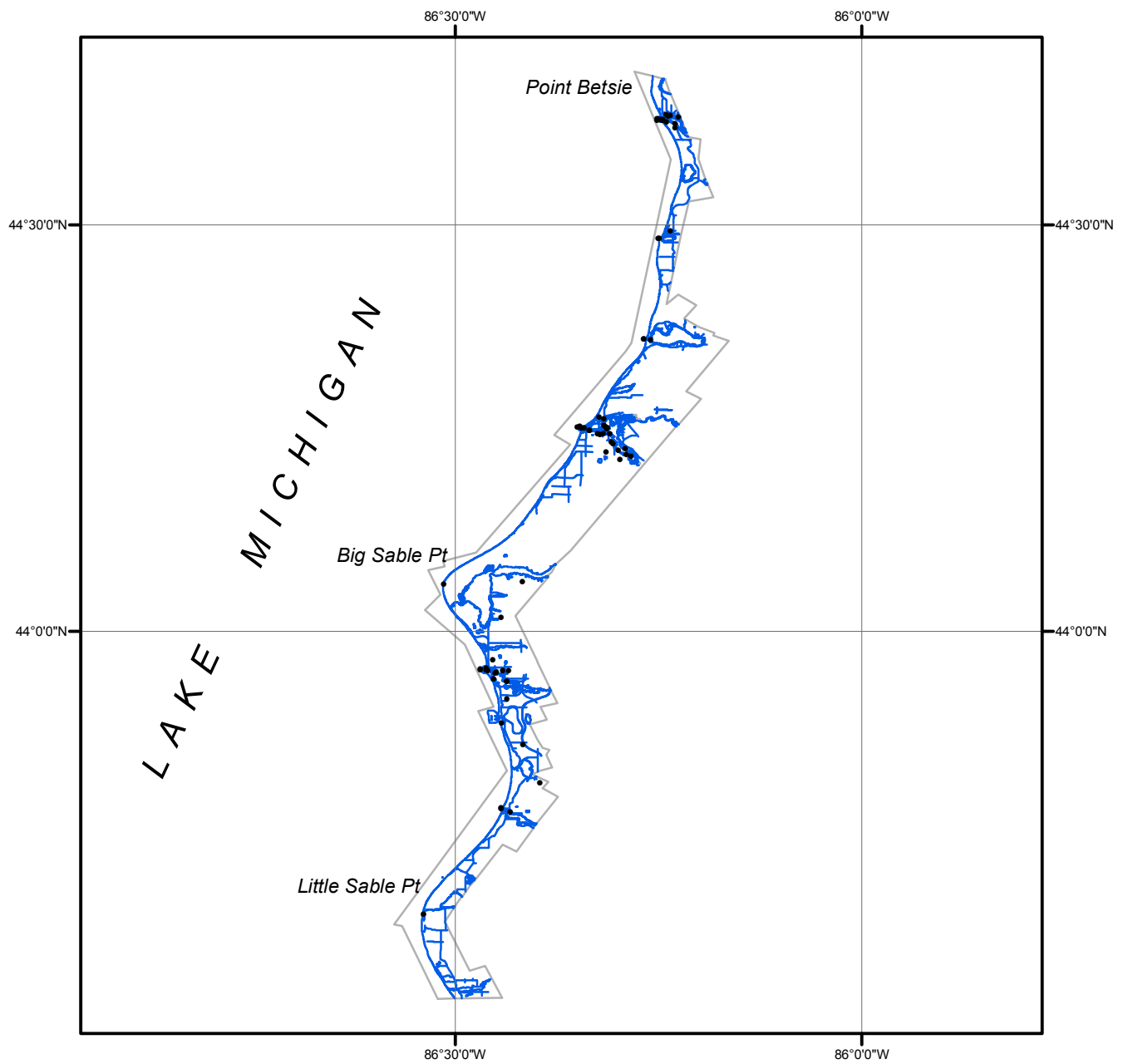
NOAA Shoreline Data Explorer

- GC11085 in shapefile format
- Metadata file for GC11085
- Digital copy of the PCR

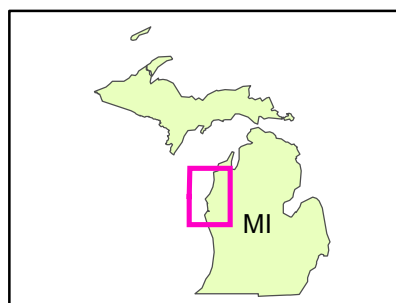
End of Report

POINT BETSIE TO STONY LAKE

MICHIGAN



Overview



MI1001F-CM-N

GC11085